Case Report

# Transcarotid Artery Endovascular Reconstruction of the Aortic Arch by Modified Bifurcated Stent Graft for Stanford Type A Dissection

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A 40-year-old man with Stanford type B dissection underwent his first endovascular repair (EVAR) in April 2004 by Talent thoracic stent graft. He had an uncomplicated recovery and maintained good blood pressure control. However, a new retrograde dissection appeared in September 2004. The new dissection involved his aortic arch and ascending thoracic aorta to the opening of the coronary arteries. To reconstruct the aortic arch, bypasses between the right common carotid artery (RCCA), left common carotid artery and left subclavian artery were performed before endovascular repair. A modified bifurcated Talent stent graft was deployed from the RCCA to the ascending thoracic aorta with a long limb in the innominate artery and a short limb in the aortic arch. A further two pieces of graft were deployed via the common femoral artery. The ascending thoracic aorta and aortic arch were reconstructed completely by the bifurcated stent graft. The final angiography confirmed that there was good stent graft configuration, normal blood flow, and stable haemodynamics. No endoleak or other major complications were encountered. This result indicated that it is possible to reconstruct the aortic arch with a bifurcated stent graft and could be a new endovascular repair model for complex thoracic aortic aneurysm and dissection. [*Asian J Surg* 2007;30(4):290–5]

**Key Words:** aortic aneurysm, aortic arch dissection, endoprosthesis, endovascular repair, stent graft

## Introduction

In recent years, endovascular repair (EVAR) with stent grafts has made great advances as a minimally invasive alternative to open surgery in the treatment of thoracic aortic aneurysm and dissection. Evolving techniques have been used to overcome the short proximal neck.[1–8] However, great difficulty has been found in treating lesions of the ascending aorta or aortic arch by the endovascular technique. The key issue is that there is no effective method of reconstructing the supra-aortic vessels. Some papers reported their initial experience. Inoue et al used a multiple branched stent-graft to exclude an aortic arch aneurysm.[7] Chuter et al repaired an aortic arch pseudoaneurysm with a modified bifurcated stent graft from the carotid artery.[1] We treated a retrograde dissection by reconstruction of the aortic arch with a modified bifurcated stent graft.

## Case report

A 40-year-old man with hypertension for 10 years had severe chest pains radiating to the back in 2001. Chest X-ray showed widening of the aortic arch in March 2004.

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Computed tomography angiography (CTA) confirmed that he had Stanford type B dissection with a maximum diameter of 7 cm. The first entry tear was located in the origin of the descending thoracic aorta, 10 mm from the left subclavian artery (LSA). The dissection extended to the left renal artery. His first EVAR, in April 2004, involved a Talent thoracic stent graft (Medtronic Inc., Minneapolis, MN, USA) with a size of 42 × 100 mm deployed in his distal aortic arch, intentionally covering the LSA, and was adjacent to the left common carotid artery (LCCA). His LSA was occluded by 10 mm, 8 mm diameter coils with a feather (Cook Inc., Bloomington, IN, USA) to prevent a type II endoleak from the LSA. He had an uncomplicated recovery and was discharged with good blood pressure control.

In September 2004, he suffered similar chest pain again and CTA showed that a new retrograde dissection had appeared. The new dissection involved his aortic arch and ascending aorta. CTA and digital subtraction angiography (DSA) were used to evaluate the morphology of the aortic dissection. There was thrombosis in the proximal false lumen to the opening of the coronary arteries and the true lumen was pressed into an ellipse (Figure 1). He had normal bilateral common carotid arteries and his LCCA had the same origin as the innominate artery. The previously placed Talent stent graft was correctly situated in the true lumen. The distance from the top of the bare stent to the right wall of the ascending thoracic aorta was only 20 mm. The coils in the LSA had moved to the origin of the left vertebral artery (Figure 2). There was a big endoleak from the first entry tear retrograde to the ascending thoracic aorta. Thrombosis in the descending false lumen compressed the true lumen into an ellipse (Figure 1). The distal exit was located at the left renal artery. There was no pleural effusion.

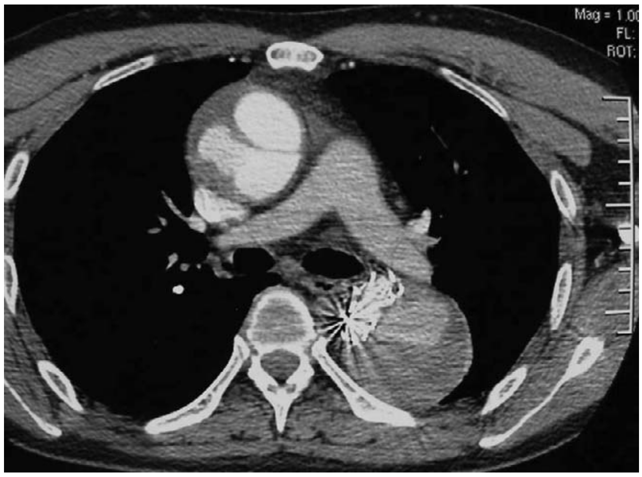


**Figure 1.** New retrograde dissection after EVAR for Stanford type B dissection.

**Figure 2.** Digital subtraction angiography shows the ascending thoracic dissection with type I endoleak. The left common carotid artery originates from the innominate artery. The coils in the left subclavian artery had moved to the origin of the left vertebral artery.

*Haemodynamic evaluation*

It appeared that the endoleak from the first entry tear involved the ascending thoracic aortic false lumen, descending thoracic aortic false lumen and LSA. Selective angiography indicated that bilateral carotid, vertebral and basilar arteries were normal with a patent anterior communication artery. The diameter of the ellipse in the ascending true lumen was 15 × 34 mm. The maximum diameter of the ascending thoracic aortic dissection was 55 mm with the thrombus in the proximal false lumen. The innominate artery diameter was 12.5 mm, right common carotid artery (RCCA) diameter was 7.8 mm, and LCCA diameter was 6.77 mm. The maximum diameter of the descending thoracic aortic dissection was 85 mm. The widest diameter of the ellipse in the descending thoracic true lumen was 20 mm. The length from the coronary arteries to the bare stent was 65 mm. The length from the coronary arteries to the innominate artery was 95 mm. The length of the innominate artery was 21.2 mm.

*Pressure measurement*

The pressure difference between ascending and descending thoracic aortas was 10 mmHg. The pressure difference between bilateral brachial arteries was 45 mmHg. Peripheral arterial examination showed normal carotid arteries, right brachial artery and femoral arteries, but with pulse deficit of the left radical artery because of LSA coiling. The diagnosis of a retrograde Stanford type A dissection after EVAR for a Stanford type B dissection was made.

*Treatment*

Based on Stanford type A dissection for a big aneurysm, it is necessary to treat actively, but the previous stent graft increased the difficulty of reconstructing the ascending and aortic arch. On the other hand, the patient refused traditional open surgery because he was afraid of great trauma. This made us design the endovascular plan for him.

The operation was performed in a catheter lab with a GE C arm (GE Healthcare, Milwaukee, WI, USA). After general anaesthesia, the RCCA was exposed and it was confirmed that a 24F delivery system could be passed. Then, the LCCA and LSA were exposed and a bypass performed between the RCCA, LCCA and LSA using a 6 mm diameter polytetrafluoroethylene graft (Edward Co., USA). Heparin was given to keep the activated clotting time between 250 and 300 seconds during the procedure. Angiography was performed to confirm that all the bypass grafts were patent. The right common femoral artery was then exposed as an access artery.

A marker pigtail was placed in the left ventricle via the right brachial artery for angiography. Another catheter from the left femoral artery was placed in the true lumen of the descending thoracic aorta for measurement of blood pressure. A 65-cm 8F sheath (Arrow Corp., USA) was placed in the aortic arch to cannulate the short limb from the right common femoral artery. A 34 × 16 × 160 mm Talent (Medtronic Inc.) bifurcated stent graft was selected. The proximal bare stent was removed. The long limb was shortened to 110 mm in length from the top of the main body (Figure 3). It was repacked into the 24F sheath. An 8F sheath was inserted into the RCCA and a Lunderquist extra stiff wire (Cook Inc.) was passed into the left ventricle. The Talent delivery system was passed into the ascending thoracic aorta along this wire. It was important to check that the ostium of the coronary arteries was properly visualized, and that the short limb was at the anterior right side prior to deployment, making the connecting bars on the long and short limb more flexible at the aortic arch and the curve of the innominate artery. The main body and the short limb of the bifurcated stent graft was deployed from the pull-back delivery system. Angiography confirmed that the coronary arteries were not covered, and then the long limb of the bifurcated stent graft was deployed completely. Sodium nitroprusside (3–10 mg/hr) was used to control the systolic blood pressure to 70–80 mmHg during deployment. Once the bifurcated stent graft was deployed, the blood pressure of the ascending thoracic aorta was increased to 140–160 mmHg. At that time, the blood pressure of the descending thoracic aorta was 120–140 mmHg. This meant that the pressure difference between the ascending and descending thoracic aorta was 20 mmHg. Another angiography confirmed that the right subclavian arteries were patent. After balloon deployment in the proximal and distal landing zone, the RCCA arterectomy was closed.

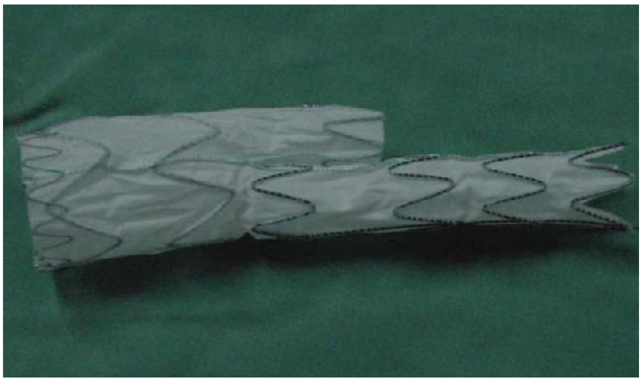

**Figure 3.** Modified Talent bifurcated stent graft, 34 × 16 × 160 mm; the proximal bare stent was removed and the main body was reduced to 110 mm in length with distal crown shape.

A multipurpose catheter was placed through the 6-F Arrow sheath of the right CFA and the short limb cannulated with a 260-cm Terumo wire. This was exchanged for a Lunderquist extra stiff wire. A Talent 16 × 16 × 80 mm limb was delivered and deployed with a proximal overlap of 20 mm in the short limb. Then, an 18 × 30 × 150 mm Ankura II (Shenzhen Xianjian Company, China) tapered customized stent graft was deployed with a proximal overlap of 30 mm on the previous stent graft and docked inside the first Talent graft. After balloon expansion of all parts of the stent graft, the LCCA and LSA were ligated proximally to the bypass anastomosis. Ascending angiography indicated good blood flow through the bifurcated stent graft without stenosis or endoleak (Figure 4). The coronary arteries and right subclavian artery were patent. There was good flow in the innominate artery and bypass grafts. Final pressure measurement confirmed that there was only 20 mmHg pressure difference between the ascending and descending thoracic aorta. This showed that it was unnecessary to do a bypass from the right subclavian

**Figure 4.** The modified Talent bifurcated graft was delivered via the right common carotid artery. The Talent limb and custom-made distal taper stent graft was delivered from the right common femoral artery. Angiogram shows normal flow and sealed proximal tear of dissection.

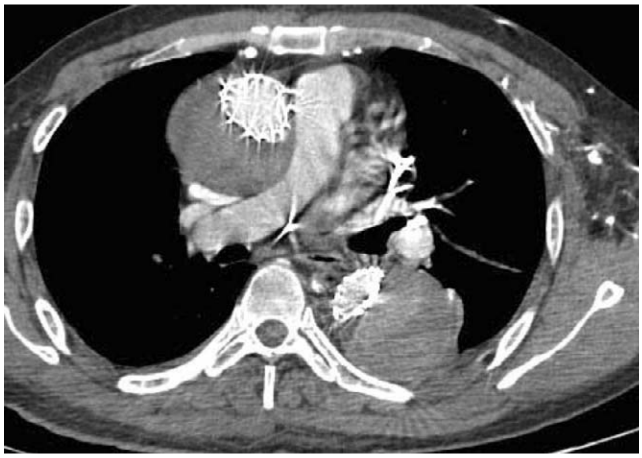

**Figure 5.** Follow-up computed tomography shows complete seal with thrombosis in the ascending and descending thoracic aortic false lumen.

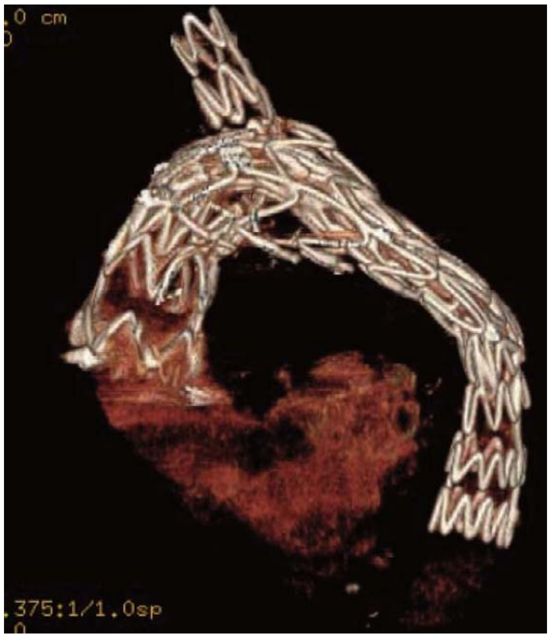

**Figure 6.** Computed tomography angiography shows the skeletal structure of the bifurcated stent graft.

artery to the right femoral artery. After withdrawal of all interventional instruments, the arteriotomies and incisions were closed. There was 3,000 mL blood loss and a 2,600 mL red blood cell transfusion during the 6-hour procedure.

Antibiotic therapy was maintained for 7 days after operation. The trachea tube was removed on the fifth day and the patient began to walk on the ninth day. No major complications were encountered, so he was discharged from hospital on the fifteenth day. CTA on day 10 indicated that there was good stent graft morphology, normal blood flow and a good seal with thrombosis in the ascending and descending thoracic aortic false lumen (Figures 5 and 6). The maximum diameters of the ascending and descending thoracic dissections were 55 mm and 70 mm, respectively. There was a little left pleural effusion.

## Discussion

Several issues have to be evaluated before operation. The most important is the possible cerebral circulation changes caused by EVAR. The patient had a normal cerebral circulation before operation, apart from previous insufficient LSA coiling. We evaluated the cerebral circulation by DSA, and this showed that he had normal right vertebral artery, basilar artery, posterior cerebral arteries, bilateral internal carotid arteries, and middle and anterior cerebral arteries. It was noted that he had a normal Circle of Willis with normal communicating arteries. This allowed adequate cerebral blood supply when any side of the common carotid arteries was clamped. The prior bypasses between RCCA-LCCA-LSA increased the safety of CCA clamping. Adequate cerebral and upper limb blood supply was possible from the 12.5-mm diameter innominate artery. With the 24F sheath inside the RCCA, cerebral perfusion was obtained from the LCCA before complete deployment, but obtained from the RCCA after reconstruction of the aortic arch.

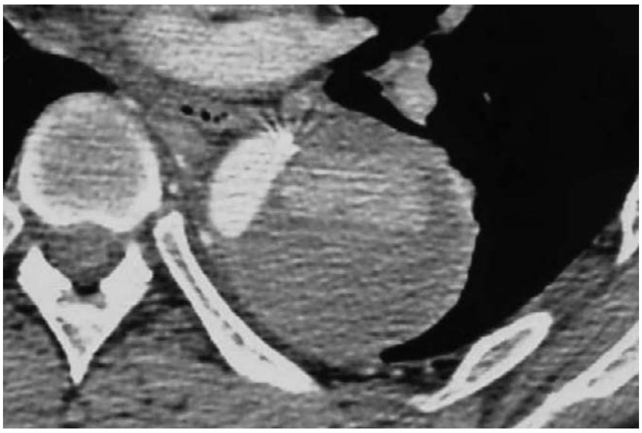

**Figure 7.** Narrowest part of the descending thoracic true lumen area before the second operation. The true lumen area was calculated to be 157 $mm^2$ ($\pi ab$ being $3.14 \times 10 \times 5$), and the area of the long limb of the bifurcated graft was calculated to be 261 $mm^2$ ($\pi r$ being $3.14 \times 8^2$).

The second issue was adequate thoracic, abdominal and lower limb perfusion after EVAR. The 16-mm diameter Talent limb had to supply all the blood to the trunk, viscera and lower limbs after operation. The feasibility of this depended on the area of the descending thoracic true lumen. There was a similar area between the 16-mm diameter circle of the stent graft and the $20 \times 10$ mm ellipse of the true lumen compressed by the false lumen (Figure 7). We monitored the pressure changes in the true lumen of the descending thoracic aorta during operation to evaluate the truncal circulation. Chuter et al used a larger short limb that would fit a thoracic extension, and this would be more appropriate for reconstruction of the aortic arch.[1]

The third issue was the evaluation of myocardial strain after the operation. Because the true lumen of the ascending thoracic aorta was compressed by the false lumen thrombus, the area of true lumen was smaller than the areas of the two 16-mm diameter stent grafts. This was adequate to prevent acute heart failure due to outflow obstruction.

Several points need to be noted with regard to the operation. The first one was the selection of the access artery. The Talent bifurcated stent graft could not be delivered through the common femoral artery because the longitudinal strut would lead to the long limb kinking and obstruction in the aortic arch. The RCCA was the easiest access. The second point was whether a 24F delivery system could pass through the RCCA. We evaluated the diameter of the RCCA by CTA and DSA preoperatively, and initially exposed the RCCA to be sure that a 24F sheath could pass through. The third point was to decide the length of the stent graft. The long limb of the stent graft should not cover the right subclavian artery (RSA) to avoid obstruction of right vertebral artery blood flow. So the stent graft was designed to fit between the RSA and the coronary arteries. We measured the length of these two points using a calibrated catheter and shortened the main body and long limb to 110 mm with a distal crown to fit the morphology of the ascending thoracic aorta and innominate artery. The fourth point was to avoid problems from the old straight stent graft. It was important to avoid passing the wire through the struts of the bare stent, otherwise the main body could not be opened. We also deployed the short limb against the anterior right wall of the ascending thoracic aorta to enable the strut of the limbs to fit the curvature at the opening of the innominate artery and aortic arch. This would allow the two limbs to open completely. This position was beneficial for cannulating the short limb from the right common femoral artery. The fifth point was how to treat the distal landing zone. Because of the Talent smaller limb, we had to obtain a custom-made taper stent graft with an 18-mm proximal diameter, 30-mm distal diameter and 150-mm length. This allowed for effective connection of the proximal and distal landing zone and avoided endoleaks.

The protocol for reconstruction of the aortic arch with an endoluminal bifurcated stent graft is a significant development for EVAR of the ascending thoracic or aortic arch lesions. Currently, EVAR of abdominal aortic aneurysm by bifurcated stent graft has been a routine technique,[9,10] but it is very difficult to reconstruct visceral or cerebral branched arteries. Although some papers reported use of a fenestrated or multiple side branch stent graft to reconstruct visceral, carotid or subclavian arteries,[11–13] the device must be custom-made. This restricts further clinical research, as these devices are only available to a limited number of surgeons and must comply with their recommendations.

This case indicates that it is feasible to reconstruct the aortic arch using a modified bifurcated stent graft through the RCCA. Transbilateral carotid arteries for reconstruction of the aortic arch using two pieces of bifurcated stent graft may be a reasonable approach for endovascular ascending thoracic aorta and aortic arch surgery. This will increase further application of EVAR and establish a new dimension for thoracic aortic endovascular surgery.

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